THE EXPOSURE HISTORY OF THE JaH 073 METEORITE L. Huber[1], B. Hofmann[2], E. Gnos[3], I. Leya[1]. [1]Physikalisches Institut, University of Bern, Switzerland, [2]Naturhistorisches Museum Bern, Switzerland, [3]Institut für Geologie, University of Bern, Switzerland. liliane.huber@phim.unibe.ch

Introduction: Large stony meteorites are relatively rare because (in contrast to iron meteorites) they fragment during atmospheric entry, producing large meteorite showers. Interestingly, many of the large chondrites, such as Bur Gheluai, Gold Basin, Jilin and Tsarev, appear to have complex exposure histories with a first-stage exposure on the parent body. The question is, whether a complex exposure history is simply more easily detected in large objects (due to multi-nuclide studies on various aliquots) or whether large objects are really more likely experience a complex exposure [1,2].

In order to check whether the observation of complex exposure histories for large objects also holds for the L6 chondrite JaH 073 we analysed various samples from this extremely well documented strewnfield and also probed the main mass (~80 kg) of this meteorite. From JaH 073 about 3000 fragments scattered in an area of about 60 km^2 were found. The total mass is approximately 550 kg, wheras the biggest fragment is about 80 kg.

Experimental: The samples with masses between 100 – 150 mg were prepared by careful cutting and cleaning. The samples were then wrapped in ~20 mg of Ni foil and loaded into the storage positions of the noble gas extraction system. To release atmospheric surface contamination, the samples were preheated at ~80 °C for various days. Gas extraction was performed in a Mo crucible held at about 1700 °C for about 35 min. A second heating step at 1750 °C performed for some samples ensures complete degassing. Gases were cleaned on Ti getters working at temperatures between 700 °C and room temperature. Argon was separated from He and Ne by adsorption on activated charcoal held at the temperature of boiling nitrogen. The measurements of HeNe- and Ar-fractions were performed using two self-made sector field mass spectrometers, one for HeNe and one for Ar. Sample gas amounts were determined by peak height comparison with signals from known amounts of He, Ne, and Ar, respectively.

Results: System blanks were determined by analysing ~20 mg of Ni foil with the same heating schedules as used for the samples. The blanks usually were below 0.5% for Ne and 0.8% for Ar of sample gas amounts, adding only negligible uncertainties to the latter. Cosmogenic ^{21,22}Ne and ^{36,38}Ar concentrations were determined from measured gas amounts by subtracting the trapped components using a 2-component deconvolution technique. For the partitioning of the Ne and Ar components we assume $^{20}Ne/^{22}Ne_{(tr)}$ = 9.80, $^{20}Ne/^{22}Ne_{(cos)}$ = 0.85, $^{36}Ar/^{38}Ar_{(tr)}$ = 5.32, and $^{36}Ar/^{38}Ar_{(cos)}$ = 0.63. While the corrections for non-cosmogenic Ne are always very minor, the corrections for trapped Ar significantly compromise exposure age studies of JaH 073. The trapped Ar component, which is of atmospheric composition, is most probable due to the large degree of terrestrial weathering. However, circumventing this problem was a major reason for probing the main mass of JaH 073 (see below).

So far we analysed 13 samples of 8 JaH 073 fragments. Duplicate analyses always give reproducible results, i.e. within the experimental uncertainties. However, for some samples Ar show slightly more scatter than He and Ne, possibly due to the rather large trapped correction. In cases where two or more analysis have been performed for one sample, average values are used for further discussion.

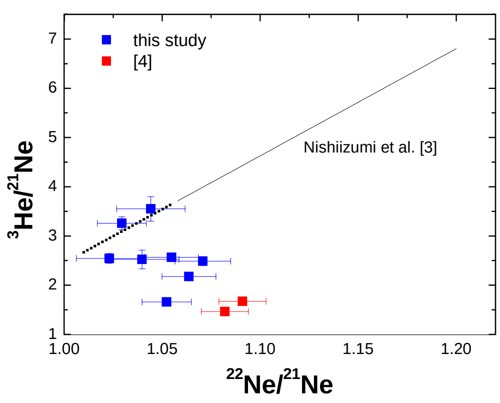

Figure 1: Cosmogenic ^{3}He/^{21}Ne versus the shielding indicator ^{22}Ne/^{21}Ne for JaH 073 samples. Also shown is the empirical correlation for chondrites given by [3] and earlier results for one JaH 073 fragment published by [4].

Figure 1 shows the cosmogenic ^{3}He/^{21}Ne ratios as a function of the shielding indicator ^{22}Ne/^{21}Ne for JaH 073 samples. For comparison, we show the empirical correlation line for chondrites given by [3] and also plot results for one JaH 073 fragment published by [4]. While two samples plot on the (extended) correlation line all other samples plot significantly below, indicating diffusive losses of ^{3}H and/or ^{3}He. However, it is not yet clear whether such losses occurred while the meteoroid was in space or whether ^{3}He has been lost due to the rather intense terrestrial weathering. Further studies to correlate ^{3}He deficits to trapped Ar amounts are currently underway.

Surprisingly, some of the ^{22}Ne/^{21}Ne ratios measured so far are between 1.04 and 1.06, i.e. significantly lower than the ratio of 1.06 assumed so far to be a lower limit for the shielding indicator. This finding confirms that JaH 073 was a large meteorite. On the other hand the results clearly indicate that the model calculations for very large meteoroids are not as good as one would like them to be and further work is needed.

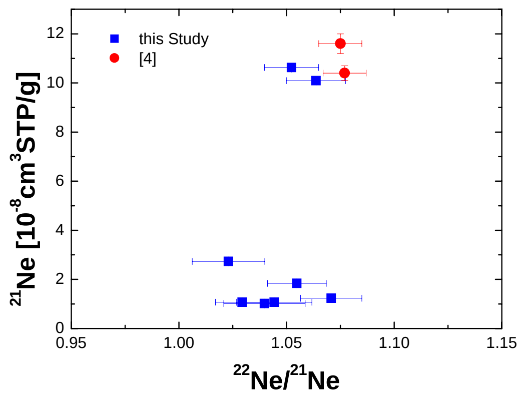

Figure 2: Cosmogenic ^{21}Ne as a function of ^{22}Ne/^{21}Ne for JaH 073 samples. The data show that exposure ages determined via ^{21}Ne would vary by up to a factor of 15.

Figure 2 depicts the cosmogenic ^{21}Ne concentrations as a function of the shielding indicator ^{22}Ne/^{21}Ne for the analysed JaH 073 samples. It can be seen that ^{21}Ne amounts, even for similar ^{22}Ne/^{21}Ne ratios, vary by up to a factor of 15, making a reliable exposure age determination impossible. For example, using the ^{21}Ne vs. ^{22}Ne/^{21}Ne production rate systematics [5], the age for JaH 073 would vary between 2 Ma and 30 Ma. Note that our results are in agreement with preliminary radionuclide data (K.C. Welten, priv. comm.). For example, the exposure age for JaH 073 determined via ^{10}Be and ^{26}Al is about 1.5 Ma. Furthermore, analysis of ^{41}Ca indicate neutron capture contributions, which clearly indicate a large preatmospheric size.

As mentioned above the Ar data are compromised by a large trapped component, which cannot be released at 80 °C (our pre-heating procedure) and which is probably due to terrestrial weathering. In order to circumvent this problem we performed various stepwise heating experiments to better separate trapped and cosmogenic components. First preliminary data indicate that the major part of the trapped component (released at rather low temperatures) is clearly of atmospheric origin. However, at about 1000 °C, i.e. after the release of most of the atmospheric contamination, we measured ^{36}Ar/^{38}Ar ratios significantly higher than in the lower (600 °C – 800 °C) and higher temperature steps (1200 °C – 1750 °C). This may indicate the presence of neutron capture ^{36}Ar. Further studies to clearly pin-down this component are presently underway.

Future work: In the next steps we try to better constrain the exposure history of JaH 073. *First*, we currently measure samples from the main mass to check whether it is possible to determine a depth profile. *Second*, the samples from the main mass are also of importance for studying the Ar isotopes, since it might be that samples from within the main mass are less affected by terrestrial weathering. *Third*, we will try to date JaH 073 using the ^{81}Kr-Kr method, and *fourth*, by combining all data we will not only be able to better constrain the exposure history of JaH 073 but also to better understand the fate of cosmogenic noble gases in highly weathered meteorites.

Finally, the study of large meteorites will be combined with dynamical model calculations of the solar system. It seems that many large chondrites really were exposed on the surface of the parent bodies before being ejected into space. Interestingly, surface studies of the asteroid 433 Eros revealed an abundance of boulders in the 2-10 m size range, i.e. similar to the size of the studied chondrites [6]. While the exposure age studies indicate that the presence of such boulders is very common and that they have survived near the surface over timescales on the order of ~100 Ma, their fate during large collisions has never been tested using dynamical model calculations.

Acknowledgements: This work is supported by the Swiss National Science Foundation. We thank the Omani government for supporting the sampling campaign.

References: [1] Welten et al. (2003) *MAPS 38*, 157-173. [2] Welten et al. (2004) *35th LPSC* #2020. [3] Nishiizumi et al. (1980) *EPSL 50*, 156-170. [4] Lorenzetti (2003) PhD. Thesis, University of Bern. [5] Leya et al. (2000) *MAPS 35*, 259-286. [6] McCoy et al. (2001) MAPS 36, 1661-1672.